Summary

At approximately 23.30 on the night of 25 September 1982 a fire, almost immediately followed by a violent explosion, occurred in a warehouse at Lower Broughton, Salford, where some 2,000 tonnes of chemicals were stored, including over 25 tonnes of sodium chlorate.

The explosion destroyed the warehouse building; there was widespread minor damage to surrounding residential property, several hundred persons were temporarily evacuated from their homes and about 60 persons attended local hospitals within three days of the incident.

There is evidence that the original fire was started outside the building by vandals and that, earlier, persons had entered the warehouse where various containers were opened and chemicals mixed. A flammable atmosphere was, in all probability, present and this allowed the fire to spread quickly to the sodium chlorate which exploded violently.

The Management of B & R Hauliers were not aware of the guidance that had been issued by the Health and Safety Executive about the storage of sodium chlorate and had evidently received insufficient information from the owners of the chemicals on whose behalf they were being stored. Although vandalism clearly played a part, the risk could have been significantly reduced had the sodium chlorate and other chemicals been stored in an appropriate manner.

The report refers to the Notification of Installations Handling Hazardous Substances Regulations 1982 in force from 1 January 1983 and the proposed changes in planning legislation described in a Consultative Document issued by the Department of the Environment. Recommendations are directed both towards employers and suppliers of hazardous materials. The report records the action proposed by HSE in relation to the preparation of additional guidance and the provision of information to those who store hazardous materials. HSE also intends reviewing the notifiable level for sodium chlorate.

History of the site

Planning

1 The buildings involved in the fire and explosion are shown on Plan 1. They were situated in the south eastern section of the City of Salford in an area known as Lower Broughton. The surrounding land is flat and the section bordered by the River Irwell, Pine Street, Flax Street and Blackfriars Road was occupied by industrial premises constructed during the 19th century. Buildings A, B and C and the adjoining yard originally formed part of Broughton Copper Works which closed in 1953. In August 1956 planning permission was granted for the use of Building A for the storage of and preparation for delivery of motor vehicles and in November 1957 planning permission was granted for the use of buildings B and C and the yard for storage and use by a firm of haulage contractors. This firm and the company to whom the assets were subsequently sold continued to use the premises for these purposes. The yard was used for the parking of vehicles and the warehouse (Building B) for loading, unloading and storage. Storage of goods could either be overnight or for long periods and the goods included oil, glue, paint and cosmetics. B & R Hauliers began to occupy Buildings B and C and the yard in 1976 and no planning application was made by this company. Such application was not, however, required because the nature of the business did not alter. The use of Building A for the storage of motor vehicles continued for a number of years. It was later used for the storage of large reels of paper and subsequently for the repair of vehicle trailers. In July 1978 planning permission was granted to B & R Hauliers at Halls Street for the erection of an extension to the existing garage for the purpose of garaging cars.

2 From the early 1960s onwards substantial housing redevelopment took place and a densely populated residential area was formed. The high rise housing to the south of Flax Street was constructed in the early 1960s and the low rise housing to the north of the Irwell during the late 1970s. Outline planning permission for further Local Authority residential redevelopment of the remaining industrial area was granted in 1976. This proposal, however, did not proceed and in 1982 planning permission was granted for a private residential development, a recreation area and a riverside walkway. The extent of this development is shown on the Central Salford Draft Local Plan which was placed on deposit in 1982, a plan from which is reproduced as Plan 2.

Demolition

3 During the years following 1976 Salford City Council bought (or will be buying) the freehold title to all the land where development is to take place and discussions have been held with the tenants of the industrial premises in order to obtain vacant possession. Assistance was given when appropriate towards finding new premises.

4 As the premises in the area were vacated demolition work was carried out by demolition companies under contract to the Salford City Council's Technical Services Department (Building Control Section). Most of the premises to the east of Halls Street had been demolished by the end of 1981; demolition of the buildings west of Halls Street continued throughout 1982.

5 For many years there had been serious problems of vandalism in this area. When premises became vacant the amount of vandalism increased, together with a large increase in the number of fires started deliberately. During the 20 months preceding September 1982, about half the fires extinguished by the local fire station personnel involved empty properties where the

cause was arson. Many other fires were extinguished by local residents and employees, without recourse to the fire brigade.

6 The more serious fires and much of the vandalism which affected the structural safety of the empty buildings caused the Building Control Section to revise, on several occasions, the order in which buildings were to be demolished.

7 The building, shown as A on Plan 1, became vacant in August 1982 and shortly after this a demolition contractor obtained the contract for demolition. It had been the intention to demolish Buildings A, B and C together; however, as Buildings B and C were not due to be vacated until October or November the demolition of Building A commenced in late August. This work involved demolition of the boundary wall shown on Plan 1 and the gradual removal of the roofing slates from Building A.

The Premises

8 The premises (the yard and Buildings B and C) which B & R Hauliers began to occupy in 1976 may be described briefly as follows. Building B was of single storey construction having a solid concrete floor and brick built walls, being approximately 80 metres (265ft) long and 31 metres (100ft) wide and 6 metres (20ft) high to eaves level. The roof structure comprised corrugated asbestos cement sheet cladding on steel purlins and steel trusses in four continuous bays with the trusses spanning between lattice girders supported on brick piers, integral with the gable walls, and intermediate cast iron columns. The south gable wall had several glazed windows and a large opening near the western corner fitted with sliding doors, which formed the main entrance to the building. The two other doors in this wall were disused and obstructed by stacked goods.

9 Internally there were two raised loading platforms, both 1.16 metres (3ft 10ins) above floor level. The smaller platform was situated in the south western corner of the building, the larger platform extended inside the south wall, to the east of the main entrance. Access to each loading platform was provided by a flight of stairs. A brick partition wall had been constructed adjacent to the north side of the smaller loading platform behind which were four large empty cylindrical storage tanks. For identification purposes the areas of the building between the lattice girders are referred to in the report as Bays 1, 2, 3 and 4, numbering from the western end. The total storage area available was approximately 2,500 sq metres (26,000 sq ft).

10 The offices used by persons employed by B & R Hauliers were situated within the warehouse on the larger loading bay; nearby these offices was a mess room and sanitary conveniences etc.

11 Parts of Building C were used as offices by the security staff (see para 16); the remaining part of the building was unoccupied.

History of B & R Hauliers

12 The company known as B & R Hauliers was established in October 1971. It became a limited company in December 1973 (A J Bloor Ltd) but continued to use the trading title of B & R Hauliers. The business was primarily road haulage and they initially occupied premises in Eccles which were used as a base for the vehicles and a repair workshop.

13 By 1976 their main activity was transporting and packing containers. The company obtained the premises at Halls Street, Salford, in 1976 (ie Buildings B, C and the yard) and this became the base for the transport vehicles which consisted of a tractor and flat bed trailer units. The warehouse (Building B) was used for storing steel and occasionally other goods in transit. The other premises at Eccles were retained for vehicle repairs.

14 During the period 1977–1979 B & R Hauliers were approached by two companies, Chance and Hunt (Proprietor Imperial Chemical Industries PLC) and N L Chemicals (UK) Ltd, for the storage of some of their chemicals. From this time onwards these two companies were B & R Hauliers' main customers. The chemicals which were usually imported were brought to the warehouse by other carriers where they were off-loaded, stored and then delivered to various companies for further processing, in vehicles belonging to B & R Hauliers. A warehousing fee was charged based on the tonnage of chemicals received.

15 In addition to the haulage service offered to the customers who used their warehouse storage facilities the company had other haulage agreements for the collection, transport and delivery of goods. For security reasons overnight parking of containers and vehicles in transit took place at Halls Street. During the week before the fire B & R Hauliers employed six drivers and had a fleet of 14 vehicles. There were three warehouse staff who reported to a warehouse manager, an accountant and a secretary.

16 B & R Hauliers employed a security company to protect their premises overnight and at week-ends. A security man arrived at Halls Street in the late afternoon and would remain there until the employees arrived the next morning; full cover was provided at week-ends. The employee of the security firm would check the premises inside and out to ensure that all was in order. This included unplugging electric fires and ensuring that fork lift trucks were switched off. During the night he would again check inside the premises at midnight and also at 6.30 as well as walking round the yard every hour.

17 Following the purchase by Salford City Council of the freehold of the warehouse and yard in September 1981 negotiations took place between the Council representatives and B & R Hauliers regarding removal to alternative premises to allow the redevelopment of the area referred to in para 2. New premises were eventually found which met some of the company's

requirements and arrangements were made for the company to move during the latter part of 1982.

18 As already mentioned in para 5, the area had been subject to vandalism and this increased when demolition commenced. When the boundary wall to Building A was demolished there were constant problems with children getting into Building A and from there into the yard. The number of fires in the vicinity increased and the management of B & R Hauliers expressed their concern to representatives of the City Council. One night children obtained entry to the yard and vandalised part of the load on a vehicle. Following further complaints to the City Council from B & R Hauliers the demolition contractor was instructed to barricade the opening from Building A into the yard. This barricade was in fact burned down on the night of 14 September, the fire being extinguished by the Fire Brigade. Further fires and vandalism occurred between the 14th and 25th. On 16 September a fire was started against the outside of the eastern wall using rubber tyres and both the police and the fire brigade were called. During the early part of the afternoon of the 25th there was a fire in the west of Building A and later that evening the employee of the security firm saw persons inside Building A and instructed them to leave.

Information about the site and premises known to the Health and Safety Executive, Fire Authority and Salford City Council

19 The premises were used as a transport undertaking and the main activity was the storage of industrial raw materials. Enforcement responsibility for the Health and Safety at Work etc Act 1974 and relevant statutory provisions rested with the Health and Safety Executive.

The Health and Safety Executive

20 The legal obligations on the company to notify their existence to the enforcing authority are referred to in para 82. No notification had been received and the Health and Safety Executive had no record of B & R Hauliers at Halls Street and had not visited the premises. However, the Health and Safety Executive had a record of the company (Swordstone Ltd) which occupied Building A and which shared a common director with B & R Hauliers. The first visit by an Inspector had been in 1981 followed by a second visit in October of that year and a final visit in May 1982 prior to demolition.

The Fire Authority

21 The premises occupied by B & R Hauliers lay within the Liverpool Street fire station area. Personnel from this station knew Lower Broughton well because they had attended a large number of fires in the area between Silk Street and the River Irwell, most of these fires being started deliberately. The fire brigade were called to the premises on the evening of 16 September to extinguish a fire (already referred to in para 18). When the fire had been extinguished a fireman used the external catwalk on the south face of the building to check whether the warehouse had been affected and another fireman entered the warehouse to check for flying embers.

22 However, as a certificate under the Fire Precautions Act 1971 was not required for the premises (see para 96) an officer from the Fire Prevention Department of the Brigade had not visited the premises and as the company had not sought advice the Brigade had no precise information about the chemicals that were being stored.

Salford City Council

23 Environmental Health Inspectors had not visited the premises as enforcement responsibility under the Health and Safety at Work etc Act 1974 rested with the Health and Safety Executive.

24 The Building Control Section of the Council supervised the demolition work in the area but had no direct involvement with B & R Hauliers; visits were however made in September 1982 about the erection of barriers in an attempt to restrict access to the yard.

25 The Planning Division of the City Technical Services Department were aware of the existence of B & R Hauliers insofar as the building lay within the central Salford redevelopment area. Negotiations about the purchase of the land and transfer of occupiers to new premises were conducted by the Valuation and Estates Division of the above Department whose representatives made several visits to the yard, warehouse and offices for this purpose.

26 The City of Salford became the lessors of the premises when they purchased the freehold of the land. The Council did not vary the terms and conditions of the lease and had no power to do so had they so wished; the only possible alteration was to vary the rent charged at the five yearly review. One clause of the lease specified that no petrol, oil or other inflammable, combustible or dangerous substances should be stored on the premises except in such quantities and subject to such conditions as any Authority should permit or require.

Description of chemicals and other goods in storage on September 25, the potential hazards and information made available

27 B & R Hauliers records regarding the chemicals and other goods in storage at Halls Street on the night of 25/26 September were destroyed in the fire and information has therefore been compiled from a number of sources. These included staff employed by B & R Hauliers, the chemical merchanting companies on whose behalf the goods were being stored, the

waste disposal company appointed to clear the premises after the fire, and from site surveys.

28 From these sources a list of the type and quantity of chemicals and goods in store has been compiled together with a plan showing their locations within the warehouse. See Plan 3 and Appendix 1.

29 The management of B & R Hauliers have stated that the stock levels in the warehouse were particularly high at the time of the fire and explosions, and all the storage space was fully utilised whilst maintaining access routes for the fork lift trucks used to handle the pallets or drums.

30 No storage areas were designated for either a particular customer or particular product, although attempts were made to keep all the stocks of one product together. There was no separation of chemical products from other goods in storage.

31 Following agreement with the chemical merchanting companies on the storage of specific chemicals B & R Hauliers had no direct control over the quantities of chemicals delivered to the premises and consequently the stock levels for each type of chemical could change substantially. Despatch instructions were received by telex from the merchanting companies and demand for individual chemicals or goods was sometimes irregular and the quantities varied.

32 Details of the hazards, appropriate precautions and actual methods of storage adopted are not described for all the chemicals in the warehouse. Those described in the following paragraphs have been selected due to their characteristics as oxidising agents or their capacity to react with such agents or because of their flammability. They influenced the course of the fire and led to the explosions when some of them were exposed to intense heat.

33 Sodium chlorate is a slightly hygroscopic colourless crystalline solid, melting point 248°C, which is readily soluble in water. It is relatively stable with decomposition commencing at 265°C with the liberation of oxygen. The decomposition is exothermic. In the United Kingdom sodium chlorate is used principally as a weed killer but also in a number of other manufacturing processes.

34 Although non-combustible when involved in a fire, sodium chlorate can decompose with the liberation of oxygen which can increase the rate of burning and flame temperature of the fire, with potentially catastrophic consequences. If the sodium chlorate becomes mixed with fuels, other organic materials and certain chemicals, the rate of burning (oxidation) is even further enhanced.

35 Sodium chlorate should be stored* isolated from ignition sources, flammable solvents, combustible materials and other chemicals either in the open air or in a fire resistant storage building. It should not be stacked on wooden pallets and the storage area/building should be posted with signs prohibiting smoking and the use of naked flames.

36 29.45 tonnes of sodium chlorate was stored in at least three locations within the main warehouse building. Packed in 50kg polythene lined steel drums, the sodium chlorate was stacked on wooden pallets. Approximately 225 drums were stored on the raised loading area against the western wall in Bay 1 (see Plan 3). Nine drums were stacked on each pallet and these were then stacked five high. At least a further 320 drums were located in Bay 3 stacked 18 drums on each pallet and these were then stacked three high. A third stack also in Bay 3 consisted of some 40 drums arranged 18 drums per pallet with some odd drums placed on top. Combustible material including orthodichlorobenzene, paradichlorobenzene and trichlorobenzene was stored adjacent to the sodium chlorate in Bay 1.

37 Sodium nitrate like sodium chlorate is also a crystalline solid and an oxidising agent. Similar precautions with regard to storage ie keep away from flammables and other chemicals, are also appropriate. If a satisfactory storage area or building had been provided for sodium chlorate, sodium nitrate could have been kept in the same store. A total of 4.2 tonnes is thought to have been in the warehouse on the night of the fire, contained in 50kg bags on pallets on the edge of the raised loading area in Bay 4.

38 Diethyl carbonate is a colourless highly flammable liquid liable to assist the spread of a fire; closed containers also burst violently when exposed to extreme temperatures. Storage of such liquids should be in accordance with the requirements of the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972 which are discussed in paragraph 86. Eleven 200kg drums on pallets were being kept in the warehouse in Bay 1 and Bay 3.

39 Approximately 10 tonnes of various chemical additives in sealed drums were stored in a number of positions in Bay 1. They contained xylene and presented similar hazards and required the same precautions as those outlined in the preceding paragraph. Some of the additives were also found to be subject to licensing under the Petroleum Consolidation Act 1928 (see para 87).

40 Orthodichlorobenzene is a colourless liquid which reacts vigorously with sodium chlorate. Some 110 tonnes were stored in sealed containers in five areas within the warehouse; additionally 15 damaged drums had been sited on the raised area in Bay 1 and had been chocked to prevent further leakage. Five dented containers were also positioned in the yard by the main door.

41 124 Trichlorobenzene is a colourless liquid which reacts vigorously with sodium chlorate and about 8 tonnes in sealed drums were being stored. These were

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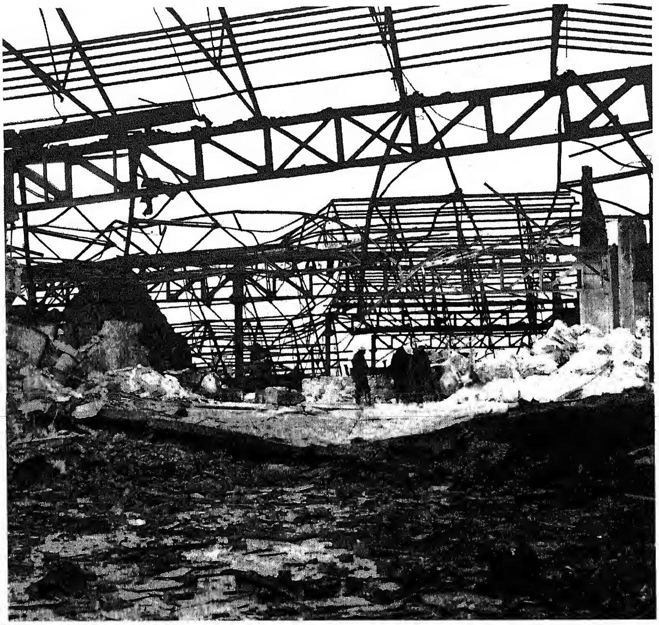
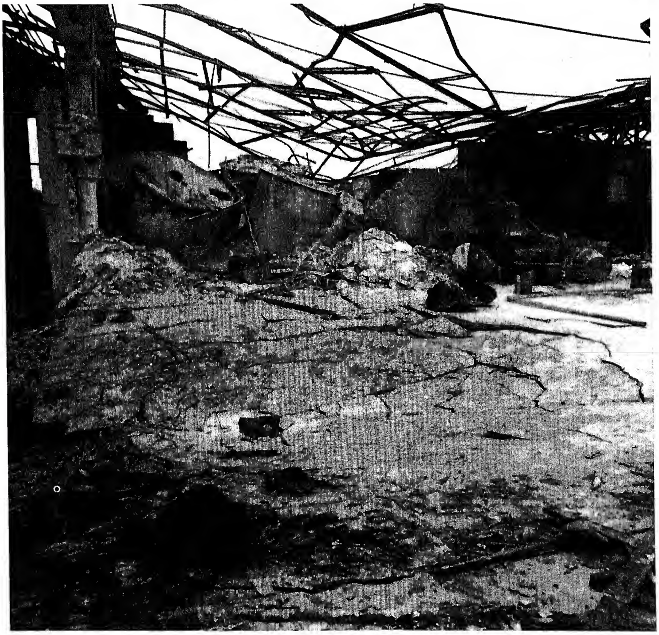
* see Guidance Note CS3; Storage and Use of Sodium Chlorate, obtainable from HM Government Bookshops

View into western end of Building B taken from Building A showing depression caused by first explosion. (Note the wall between the two buildings was demolished by the explosion.)





View of depression on raised area at western end of Building B located on the raised section of Bay 1 adjacent to the sodium chlorate.

42 Crystalline paradichlorobenzene is a flammable solid which will also react vigorously with sodium chlorate from which it should be stored separately. Contained in 25 kg sacks and stacked 50 sacks per pallet and two pallets high, 262 tonnes were in the warehouse on the night of the fire. Mainly stored in Bay 4, some sacks were located on the raised area adjacent to the sodium chlorate in Bay 1.

43 As indicated in paragraph 95 the general requirements of Section 6(4) of the Health and Safety at Work etc Act 1974 and the requirements of the Packaging and Labelling of Dangerous Substances Regulations 1978 did not apply to the transfer of the chemicals to B & R Hauliers because they were neither sold to B & R Hauliers nor supplied to them for use at work or for further processing. In addition the Regulations would not apply to proprietary mixtures.

44 Nevertheless, drums containing sodium chlorate in the warehouse were labelled with a yellow diamond pictogram and marked oxidising agent. A warning stating 'powerful oxidising agent may cause fire' and certain supplementary guidance eg 'do not store on wooden floors' was also contained on the label. If they had been applicable the Packaging and Labelling of Dangerous Substances Regulations 1978 would have required the wording for the indication of risk to have read 'Explosive when mixed with combustible material' and 'Harmful by inhalation and if swallowed'.

45 The containers of the xylene based additives (proprietary mixtures) were labelled with a square orange pictogram with a black cross and the word 'flammable'. The guidance phrases included 'Keep away from Sources of Ignition – No Smoking'.

46 Guidance in connection with sodium chlorate was supplied to B & R Hauliers by Chance and Hunt. The guidance gave information about the hazards; guidance on storage was, however, restricted to 'Do not store on wooden floors' and 'Keep away from heat, naked flames or sparks, acids and combustible materials'. The transport emergency cards were designed to give guidance only in the event of incidents during conveyance by road and did not include information about storage.

47 Representatives of Chance and Hunt paid at least 14 visits to the warehouse during the 12 months period prior to the fire, primarily for the purposes of stock control. The company was satisfied with the service that B & R Hauliers were providing. Chance and Hunt were however of the opinion that as they were paying for this service it was the responsibility of B & R Hauliers to store the substance in a safe manner. They therefore did not take the opportunity at these visits to comment on the actual storage arrangements. The guidance produced by the Health and Safety Executive was not known to the management of B & R Hauliers (see para 35).

48 Representatives of N L Chemicals paid occasional visits to B & R Hauliers. They also were satisfied with the service that was being provided. N L Chemicals gave no information about storage arrangements for their products, being of the opinion that as B & R Hauliers were a professional warehouse company they expected them to have the necessary knowledge and take appropriate precautions. B & R Hauliers were not aware of the guidance that the Health and Safety Executive had issued about the storage of highly flammable liquids (see para 86).

The fire and explosions

49 At approximately 23.20 hours on 25 September the night watchman left the gatehouse to carry out his routine hourly inspection. He went into the yard and checked the main warehouse entrance, the diesel pump and parked vehicles. As he was walking towards a parked container on his way back to the gatehouse he heard 'a noise like thunder' followed by 'a very loud bang'. He thought that he fell to the ground and remembered on turning around seeing flames shooting out of a hole in the roof of the warehouse near to the adjacent empty building (Bay 1).

50 At about the same time a resident in one of the nearby tower blocks of flats overlooking the premises saw a fire at the east end of the warehouse building. Her call to the fire brigade was logged in at 23.28 hours and ended just after 23.29. On returning to her vantage point she saw the fire develop quite rapidly and saw two persons running away from it. The fire was then seen to 'roll' quite quickly from the east end of the building to the west end and within a very short period of time the most violent of all the explosions associated with this incident occurred. It is estimated that this was within 30 seconds of the initial fire call to the fire brigade.

51 At approximately 23.32 hours the fire brigade arrived at the scene. They observed fires at both the east and west ends of the building and within two or three minutes a second explosion occurred at the west end of the building.

52 From this time onwards the major fire was concentrated around the east end of the building and at about 23.45 hours the third of the explosions occurred in this position. Further minor explosions occurred during the next five to six hours.

53 Following police investigations into the circumstances of the fire and explosions five persons faced charges of burglary and two of these five faced additional charges of arson.

Investigation

54 The first report to the Health and Safety Executive was received at 7.25 hours on the morning of the 26 September by the Area Director for Greater Manchester in a telephone call from the Environmental Health Department of the City of Salford. He arrived

at the site shortly after 9.00 hours and was joined by other Inspectors whom he had contacted by telephone.

55 By this time the fire was under control and damping down operations were being carried out. For the reasons given below it was not safe or practicable to commence detailed investigations on the Sunday; these began the following morning.

56 Arrangements were made for specialist and scientific support staff from the North West Field Consultant Group to assist in the investigations together with scientists from the Research Laboratory Services Division. They worked closely with the police, the fire authority, forensic experts from the Home Office, the Petroleum Licensing Authority and a number of the departments of the City of Salford.

57 Investigations within the warehouse presented a number of problems, principally the structural instability of the remains of the building. For this reason two Prohibition Notices were issued by the Health and Safety Executive, one to the City of Salford as owners of the premises and the other to the occupiers, B & R Hauliers. The Notices were designed to restrict access into the premises only to authorised persons.

58 HSE inspectors and scientific staff concentrated their investigations upon the causes of the fire and the explosion and the effects of these both upon the premises and the surrounding area. The records of B & R Hauliers about the chemicals and other stock held in the warehouse had been destroyed in the fire. Details of the stock held on the night of the incident had therefore to be obtained from the merchanting companies, from interviews with staff employed in the warehouse, by physical examination of the site by inspectors and from the inventory compiled by the contractors subsequently engaged to clear the site. The full list of chemicals and their position in the warehouse took nearly a month to complete.

59 The extent of the damage and contamination outside the site was investigated in close liaison with departments of the City of Salford, particularly the Environmental Health Department who have statutory roles in connection with environmental pollution.

60 In addition to the investigation of the incident, inspectors from the Health and Safety Executive continued to be closely involved with site clearance work and demolition operations giving advice on methods and precautions to the contractors appointed by the City of Salford. Clearance of the site was completed during the first week of November having commenced as soon as the site was released to the Council on the afternoon of Friday, 1 October.

Injury, damage and other effects of the fire and explosions fire

61 The only person on the premises at the time of the initial explosion, the night watchman, escaped serious injury. Damage within the B & R Hauliers site and the adjacent empty buildings was extensive and included collapsed roof structure and collapsed damaged walls.

62 Within the yard and warehouse a number of vehicles were totally destroyed or severely damaged. Much of the stock, both chemicals and other goods, was either destroyed or damaged by the fire, explosions or water used during the fire fighting operation: some of the stock and vehicles were, however, subsequently salvaged.

63 Two depressions were discovered within the warehouse. The first and most violent of the explosions had its epicentre at the west end of the warehouse (see Plan 5) and was marked by a deep depression 8.5m diameter and 90cm in depth in a 9cm thick reinforced concrete floor. Estimates of the TNT equivalent of this explosion have been made from close field (door, windowframe, roof) damage, far field (window) damage and from examination of the depression. The damage was generally consistent with a TNT equivalent of up to a tonne (2,205 lbs).

64 A second depression located at the east end of the building (Plan 5) marked the third explosion at 23.45 hours. The explosion which caused this depression was apparently less energetic than the first one; the depression was approximately 7.6m in diameter and 23cm deep.

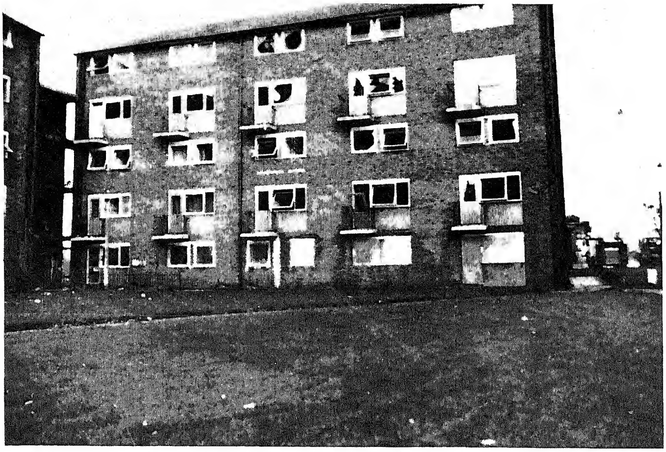
65 The effects of the explosion and fire beyond the site resulted in about 60 persons attending local hospitals within three days of the incident.

66 The majority were suffering from the effects of inhaling smoke and fumes and from shock. One person with breathing difficulties was admitted into hospital for 24 hours. Nine persons were treated for cuts and lacerations, one for an eye injury and four for nausea and vomiting. About 100 persons are known subsequently to have attended Salford Royal Hospital complaining of chest ailments, sore throats, the effects of fumes or simply seeking advice following publicity about chemicals emitted into the atmosphere as a result of the explosions and fire.

67 Many flats and houses sustained damage, particularly to roofs and windows and at the height of the fire several hundred people were evacuated from their homes. Plan 4 shows the extent of the physical damage around the site together with the location of parts of drums, girders etc.

68 The area, particularly the housing estate to the north of the warehouse, was contaminated by a white powder and traces of this were found several miles away. Sampling of the powder by staff from the Health and Safety Executive Field Consultant Group and the Greater Manchester County Laboratory indicated that this was mainly titanium dioxide with some traces of paradichlorobenzene, projected into the atmosphere by the explosion and the thermal currents created by the fierce fire that followed. Titanium dioxide is innocuous and the properties of paradichlorobenzene

Measuring depth of water filled depression in Bay 3



Damage to Bradwell House

are such that it would have dissipated safely by evaporation.

69 Fears that lead pigments had also contaminated the area appeared to be unfounded. Most of the organic pigments were later discovered in the warehouse during the operations to clear the site.

70 The hydrogen chloride gas liberated by the reaction of water with the aluminium chloride, which appeared as a dense white cloud in the damp atmosphere, was a potential cause for concern during the early stages of 'damping down'. Fortunately, the amount of gas liberated was relatively small and dispersed quickly.

The cause of the fire and initial explosion

71 The most probable cause of the outbreak of fire within the warehouse was the fire started externally between 22.30 and 23.00. This fire entered the building probably by the roof and the rapid 'rolling' of the fire described by the eye witness could have been attributable to a flammable atmosphere at low level within the building.

72 It is possible that acts of vandalism had been committed earlier in the evening but it will probably

Buildings A, B and C after the fire.

never be known exactly what 'cocktail' of chemicals was mixed or which flammable liquids were spilled as a result.

73 The rapid spread of the fire from east to west along the building may have resulted if flammable liquids had been discharged from their containers or if control valves on liquefied petroleum gas cylinders had been opened, but this latter suggestion is considered to be unlikely.

74 It may also be possible that another fire started elsewhere within the building as a result of vandalism or from some other cause; however there is no evidence to support this possibility and it is thought to be unlikely.

75 Once the fire reached the west end of the building the available evidence supports the view that the 11 tonnes of sodium chlorate stacked there on wooden pallets exploded violently in less than one minute.

76 In previous explosions involving sodium chlorate, for example, the fire and explosions at Braehead

container depot, Renfrew, on 4 January 1977*, the most likely mechanism by which the substance was thought to explode was by drums of sodium chlorate being exposed to an intense fire and proceeding to an explosive decomposition with no fuel being involved in the reaction.

77 In this incident an alternative mechanism is suggested by two factors, namely, the violence of the explosion and the short period during which the 11 tonne stack was involved in the fire.

78 One theory postulates a drum surface effect involving sodium chlorate, polythene liner and steel. The basis for this is that the short period between the fire engulfment of the chlorate drums and their subsequent explosion only allowed time for the drums to heat up, melt the liners and thus induce decomposition of the chlorate close to the surfaces of the drums. This exothermic reaction would be intensified by the presence of the hot steel if this becomes involved in an oxidisation/combustion type of reaction.

79 An alternative mechanism is that explosive energy could be produced, by the scattering contents of bursting sodium chlorate drums reacting with the vapour from spilled solvents.

80 A further theory involves sodium chlorate being contaminated either accidentally or deliberately (by vandal action) with organic materials such as the adjacent dichlorobenzene. If such contamination had preceded the fire engulfment, subsequent contact with fire would produce the classical explanation of fuel + oxidiser + heat initiation giving explosion.

81 However, none of the above theories can be confirmed or otherwise by an examination of the evidence arising out of this incident.

Legislation

82 The premises occupied by B & R Hauliers were subject to the Health and Safety at Work etc Act 1974 and constituted a warehouse subject to certain sections of the Factories Act 1961. There was no duty under these sections to notify the existence of the warehouse to the enforcing authority. The offices within the warehouse were subject to the Offices, Shops and Railway Premises Act 1963. Section 49 of this Act requires notification of any office where more than 21 hours a week of 'office work' are carried out. No notification had been received.

83 The fire and explosion was notifiable to the Health and Safety Executive in accordance with the Notification of Accidents and Dangerous Occurrences Regulations 1980 and a notification was received.

84 The premises were also subject to certain regulations made under the Factories Act and the Health and Safety at Work etc Act 1974, namely the Electricity (Factories Act) Special Regulations 1908 and 1944, the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972 and the Control of Lead at Work Regulations 1980.

85 A highly flammable liquid is defined by the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972 as being a liquid which when tested in the manner described in the Schedules of these Regulations has a flashpoint of less than 32°C and supports combustion. Some of the chemicals stored in the warehouse came within this category.

86 Regulation 5 of these Regulations refers to the storage of highly flammable liquids. These are required to be stored in suitable fixed storage tanks in safe positions or in suitable closed vessels kept either in a safe position in the open air or in a storeroom which either is in a safe position or is a fire resisting structure. A Guidance Note on how compliance with this Regulation may be achieved has been published by the Health and Safety Executive*. No arrangements had been made to store highly flammable liquids in accordance with this Regulation.

87 Regulation 5 does not apply where the highly flammable liquids are petroleum spirits as defined in the Petroleum (Consolidation) Act 1928 and which are authorised to be kept by a licence issued under that Act. Samples of certain of the chemicals were subsequently tested by the Petroleum Licensing Authority and were found to be petroleum mixtures. The licensing authority advised that no licence had been applied for or issued.

88 Regulation 7 deals with the storage of liquefied petroleum gas (LPG) cylinders which should be kept in safe positions in the open air or in a well-ventilated storeroom in a safe position or in a fire-resisting structure. A number of cylinders were kept within the general warehouse building and not in a storeroom.

89 The Control of Lead at Work Regulations 1980 specify precautions to be adopted when lead or lead compounds are processed or handled. The lead chromate in the warehouse was subject to both handling and repacking following damage to bags. Regulation 4 requires that where any work may expose persons to lead the employer should assess that work to determine the nature and degree of exposure to lead. No assessment had been made.

90 In addition to the specific requirements of the above Regulations the Health and Safety at Work etc Act 1974 imposes wider general requirements on B & R Hauliers.

91 Section 2(1) of the Act places a duty on an employer to ensure so far as is reasonably practicable the health,

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*The fire and explosion at Braehead container depot, Renfrew, 4 January 1977 – Health and Safety Executive report by HM Factory Inspectorate.

*Guidance Note CS2, the Storage of Highly Flammable Liquids, obtainable from HM Government Bookshops.

safety and welfare at work of all his employees. This duty extends to include:

(a) arrangements for ensuring so far as is reasonably practicable safety and absence of risks to health in connection with the handling, storage and transport of articles and substances, and

(b) the provision of such information, instruction and supervision as is necessary to ensure so far as is reasonably practicable the health and safety at work of his employees.

92 Whereas the storage (and use) of highly flammable liquids are controlled by the Regulations described in the preceding paragraphs the storage of sodium chlorate and other chemicals is subject to the general provisions of the Health and Safety at Work etc Act 1974. Advice on the appropriate methods of storing sodium chlorate has been published by the Health and Safety Executive*. The sodium chlorate was not stored in the warehouse in accordance with that guidance.

93 Section 2(3) of the Act requires the employer to prepare a written statement of his general policy with respect to the health and safety at work of his employees and his organisation and arrangements for carrying out that policy. An employer who carries on an undertaking in which for the time being he employs less than five employees is exempted from this requirement. No written statement had been prepared by B & R Hauliers.

94 Section 3(1) of the Act places a duty on an employer to conduct his undertaking in such a way as to ensure so far as is reasonably practicable that persons not in his employment such as members of the public are not exposed to risks to their health and safety. The effects of a fire or explosion arising from the presence of sodium chlorate and other chemicals included the likelihood of injury both to employees and to members of the public, namely residents living nearby. Consequently the precautions that were necessary to secure safe storage had a dual role to protect both employees and the public. The merchanting companies who retained ownership of the chemicals whilst they were in the warehouse may have had duties under Section 3(1), namely to provide adequate information on methods of storage (see paras 46–48).

95 Section 6(4) of the Act which requires suppliers to give information about any conditions that are necessary to ensure that a substance will be safe applies only to substances supplied for use at work. The various chemicals were sent to B & R Hauliers for storage during the chain of supply and were not for their use at work. The Packaging & Labelling of Dangerous Substances Regulations 1978 did not apply to the chemicals for a similar reason. (Revised Regulations are currently in draft.) However, certain of the chemicals which had hazardous properties were not labelled precisely in accordance with these Regulations or by other methods which the Regulations allow (see paras 43 and 44).

96 The Fire Precautions Act 1971 was enforced by the Greater Manchester Fire Authority but as the use to which the premises was put has not been designated under Section 1(2) of the Act a fire certificate was not required. The premises were not subject to the Fire Certificates (Special Premises) Regulations 1976 because the activities undertaken did not fall into any of the categories of premises listed in the First Schedule to these Regulations.

97 The Fire Services Act 1947 empowers the Fire Authority to gather information for fire fighting purposes and to this end it is of course helpful if Fire Authorities are alerted to potential hazards for example by requests for advice or guidance from firms. No such request had been received by the Fire Authority from B & R Hauliers.

98 Planning control over the premises was exercised by the City of Salford. The premises at Halls Street were considered to fall within Class X of the Schedule to the Town & Country Planning (Use Classes) Order 1972. In 1957 the use of the premises for road transport and storage purposes was granted under the 1947 planning legislation. Although occupation changed between 1957 and 1982, there was no material change in the general nature of usage (see para 1); consequently a further planning application was not necessary.

99 Because in excess of 25 tonnes of sodium chlorate was stored in the warehouse the existence of this material would have been notifiable to the Health and Safety Executive by virtue of the Notification of Installations Handling Hazardous Substances Regulations 1982 in force from 1 January 1983.

Conclusions and comments

100 Although the precise mechanism of the explosions has not been established it seems fairly certain that these explosions were caused by the sodium chlorate being exposed to a substantial fire. Although arson and vandalism clearly played a part, the risk could have been significantly reduced had the sodium chlorate and other chemicals, particularly flammable solvents, been stored in an appropriate manner. As the booklet, published by the Health and Safety Executive, entitled 'Managing Safety'* points out, the management of every undertaking needs to be aware of the possible hazards in its activities and one of the key elements is knowledge and its effective distribution and use.

101 During the course of the investigations the Health and Safety Executive were informed by B & R Hauliers that they first began to store sodium chlorate in the warehouse some twelve months before the

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*Guidance Note CS3 Storage and Use of Sodium Chlorate obtainable from HM Government Bookshops.

*Obtainable from HM Government Bookshops.

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incident. However, their records had been destroyed in the fire and there had been staff changes. Chance and Hunt were clearly under the impression that B & R Hauliers had previous experience of the storage of sodium chlorate on behalf of another chemical merchant. A report of a visit that one of their representatives made to the warehouse in 1977 which Chance and Hunt subsequently made available to the Health and Safety Executive supports this conclusion. Nevertheless, had B & R Hauliers consulted, for example, the Health and Safety Executive to ascertain the hazards and the necessary precautions and had they been adequately advised by the chemical merchants, B & R Hauliers may well have come to the conclusion that they could not meet the standards without making alternative arrangements. In addition, for those flammable liquids which were subject to licensing under the Petroleum Consolidation Act, the Licensing Authority would have imposed their own requirements which B & R Hauliers might have found difficult to meet. More detailed information about the materials stored in the warehouse might possibly have influenced the City of Salford to have altered the timing of the demolition of the building adjacent to the warehouse. B & R Hauliers might perhaps have been relocated before any demolition began and this could have reduced the risk of vandalism which so often accompanies demolition work.

102 The Health and Safety at Work etc Act 1974 has recognised that safety cannot be achieved by allocating responsibility in discrete and watertight compartments. In any situation it is likely that a number of persons may have a part to play. This concept can be seen for example in the general provisions of Sections 3 and 4 of the Act; to ensure compliance persons need to consider what part it is reasonably practicable for them to play in the particular situation. This may involve no more than giving information which the recipient can then use to devise systems of work which will ensure that his own activities are conducted safely, both in respect of his own employees and others who may be affected. It is known that some companies handling hazardous substances provide information and advice to transport and warehousing contractors and in some cases train the contractors' employees. Had the chemical merchanting companies on whose behalf B & R Hauliers were storing the materials given more precise information about appropriate methods of storage B & R Hauliers might have responded to that advice in the way already suggested thereby reducing the risk of fire and explosion occurring.

103 These general provisions can be applied to all situations irrespective of the magnitude of the hazard. There are circumstances, however, where the failure of individuals to respond to the general duties which the Act imposes on them may have particularly serious consequences. It is for this reason that other controls may be necessary. The Notification of Installations Handling Hazardous Substances Regulations 1982 in force from 1 January 1983 require persons undertaking any activity involving the use of defined quantities of certain materials to notify the Health and Safety Executive.

104 The Regulations and the proposed complementary planning controls were chosen to deal with major threats to safety where, if an incident occurred, there might be substantial loss of life or serious injury outside the confines of the workplace following fire, explosion or the escape of toxic materials. The selection of the listed substances and, particularly, the threshold quantities of each, necessarily involved an element of judgement and was based on advice from the Advisory Committee on Major Hazards and the various bodies who were consulted during preparation including manufacturers, trades unions and local authority associations. The Advisory Committee took the view at the time that lesser quantities presented a lower hazard best dealt with in accordance with current practice and by enforcement of current safety legislation. Incidents such as this do lead to the suggestion that more substances should be included and that the threshold levels should be lowered. Clearly the notifiable quantities listed in the Regulations need to be kept under review and the evidence provided by this incident would seem to justify reconsideration of the level for sodium chlorate.

105 The warehouse would have been a notifiable installation because more than 25 tonnes of sodium chlorate was held in store.

106 The Regulations, which are the first step in a series of measures, will provide the Health and Safety Executive with a comprehensive picture of the numbers and distribution of hazardous installations. The nature and location of these installations will be passed by the Health and Safety Executive to the local planning authority and to the emergency services. The second step will be to improve planning controls over hazardous installations particularly with a view to closing, where possible, existing loopholes which allow some premises to move into the category of "hazardous installations" without specific planning consent. The Department of the Environment published on 26 August 1982 a consultative document* on possible changes in the planning laws and is considering what changes should be made, in the light of comments received. Meanwhile the Department has advised planning authorities (in circular 26/82) to continue to operate the consultation arrangements described in circular 1/72 but to apply them to hazardous installations as defined in the Notification Regulations. The third step in the series will be implementation of the EC directive on the Major Accident Hazards of Certain Industrial Activities. This will require persons in charge of some industrial activities to carry out hazard surveys, prepare on-site emergency plans and to make available

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*"Planning Controls and Hazardous Development" issued by the Department of the Environment

information for members of the public who might be affected by an incident. Competent Authorities will be required to draw up off-site emergency plans.

107 This incident highlights the problems of the control of hazardous materials in warehouses and the HSC has already drawn the attention of the Department of the Environment to the possibility of all warehouses which become notifiable installations being made subject to specific planning controls. HSE will be bringing this matter before the HSC again.

108 However, there may still be incidents causing public alarm at sites which do not come within the scope of the new Regulations. Two suggestions have been made in the public debate on the Salford and similar incidents. The first is that the Regulations – and the complementary changes in planning legislation – should bring within their scope any quantity of any hazardous substance. This would increase the number of sites to be controlled under such a regime to unmanageable proportions. Applications of such controls to small quantities is unnecessary since the effects of incidents would be comparably small.

109 The second suggestion is that a local authority licensing scheme for the storage of hazardous substances should be introduced. To superimpose licensing on the existing requirements of the Health and Safety at Work etc Act and Regulations made under the Act would involve duplication and overlap of responsibilities and be inappropriate in view of the statutory requirements and enforcement arrangements already in existence. In HSE's opinion such a scheme is unworkable and should not be considered.

110 Statutory requirements in support of the wide-ranging general duties under the Health and Safety at Work etc Act include the Packaging and Labelling of Dangerous Substances Regulations 1978 as amended. The HSC has published a consultative document with a view to strengthening these provisions. They could be complemented by requirements for notification and marking of buildings containing dangerous substances, in part for the benefit of the emergency services; ways of achieving this are under active consideration by HSE. HM Factory Inspectorate has already embarked on a national survey which it is hoped to complete during 1983, to identify establishments storing one tonne or more of sodium chlorate, to inspect the methods of storage and to make sure that those concerned are in possession of appropriate guidance.

Recommendations

111 All suppliers of hazardous materials should pay particular attention to ascertaining how their goods are to be stored and handled in transit and provide information necessary to ensure that those who store or handle the materials can do so safely. This would be in addition to their statutory duty under Section 6 of the Health and Safety at Work etc Act to make available adequate information to ensure that substances for use at work are safe and without risks to health when properly used.

112 All employers should ensure that adequate precautions are taken so that, in the event of a fire on their premises, the risk of its spreading to hazardous materials in storage or in transit, and thus giving rise to a more serious fire or explosion, is prevented.

113 In particular, employers should:

(a) ensure that they have obtained all the information necessary about such hazardous materials from the manufacturer, importer or supplier to enable them to take appropriate precautions, particularly when they are stored in densely populated areas;

(b) ensure that particularly hazardous materials are segregated from others where their chemical properties justify it;

(c) consider risks that are reasonably foreseeable from vandalism and from arson and take such additional steps as are necessary to protect their premises and materials in storage.

Action by HSE

114 HSE will ask the HSC to consider whether Section 6 of the Health and Safety at Work etc Act should be extended to require the provision of advice, by suppliers of hazardous materials, to those who store and handle such materials.

115 HSE will review the notifiable level for sodium chlorate under the Notification of Installations Handling Hazardous Substances Regulations 1982. Any review would include consideration of the need for further limited study by the HSE (with outside participation if necessary) of specific questions which remain unanswered about the behaviour of sodium chlorate in fires.

116. HSE will review the contents of Guidance Note CS3, Storage and Use of Sodium Chlorate, and consider the need for additional guidance, for those who handle or store chemicals, on the incompatibility of certain substances for storage in close proximity to one another.

117 HSE will consider ways in which information about the handling and storage of hazardous materials, in quantities less than those notifiable under the Notification of Installations Handling Hazardous Substances Regulations 1982, should be made available to those who need it, including the Fire Brigades.

Appendix 1 Goods in storage, within the warehouse

Chemical	*Packaging*	*Total Quantity*
Chance and Hunt		
Sodium chlorate	50 kg drums	29.450 tonnes
Sodium nitrate	50 kg bags	4.2 tonnes
Diethyl carbonate	200 kg drums	2.2 tonnes
Orthodichlorobenzene (various grades)	250 kg drums	109.865 tonnes
124 trichlorobenzene	285 kg drums	7.980 tonnes
Paradichlorobenzene	25 kg bags	261.86 tonnes
Wood cellulose	25 and 35 kg bags	6.81 tonnes
Diglyme	194 kg drums	2.34 tonnes
Aluminium chloride (various grades)	275 kg drums	452.375 tonnes
Aluminium chloride (powder)	50 kg bags	1.0 tonnes
Magnesium chloride	50 kg bags	5.45 tonnes
Stannous chloride	50 kg bags	2.49 tonnes
NL Chemicals (UK) Ltd		
Titanium dioxide	bags	938.55 tonnes
Lead chromate/organic pigments	bags	89.754 tonnes
Xylene based Additive 60X	170 kg drums	6.12 tonnes
Xylene based Additive 1078X	170 kg drums	3.4 tonnes
Xylene based Additive 2000X	16 & 170 kg drums	1.1 tonnes
Other chemicals	bags or drums	43.198 tonnes
Other companies		
Iron oxide	25 kg bags	5 tons
Rubber (various grades)	wooden crates	unknown
Currants	12.5 kg bags	6 tonnes

Appendix 2 TNT equivalent calculations

1 *Crater Size*

Using the Olsen formula

$$V = K\,Q^{8/7}$$

where V = volume of crater
K = constant
Q = equivalent weight of TNT in lbs
After Robinson (ref 3) K = 0.4 for dynamite
K = 0.113 for ammonium nitrate
ex Oppau (1921) incident

$$\text{here then } Q = \left(\frac{V}{0.133}\right)^{7/8} = \left(\frac{938}{0.133}\right)^{7/8} = 2686 \text{ lbs}$$

ie 1.2 Tonne.

Note: This estimate is imprecise because the depression in the concrete was not a true crater; the concrete was pushed down into the supporting hardcore.

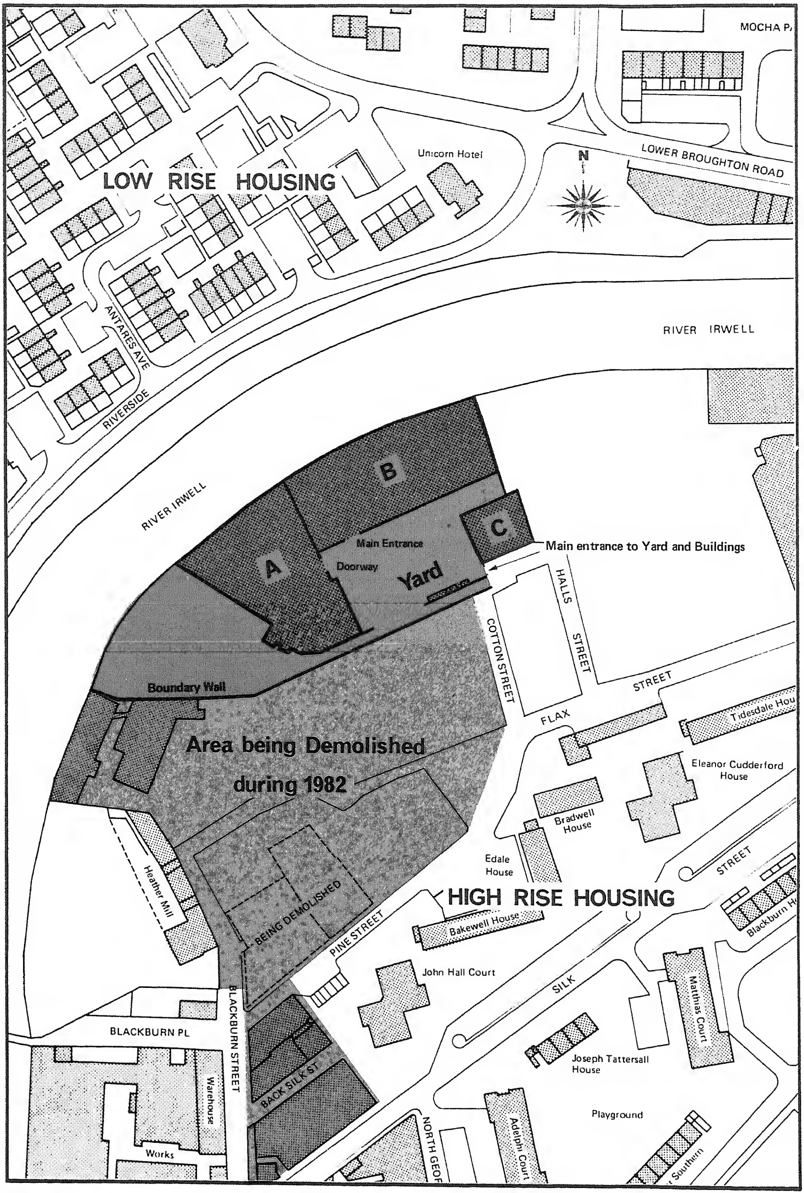
2 *Window Damage*

5% window damage up to a distance of 550m (1804ft). The sealed distance for the corresponding 0.1 psi is approx. 155 (refs 3 & 4). This gives a TNT equivalence of approx. 1570 lbs *(0.7 Tonne)*

3 *Window Frames & Doors*

Some window frames and doors blown in up to a distance of 171m (561ft). The sealed distance for a pressure of 0.5 psi is 52. This gives a TNT equivalence of 1255 lbs *(0.6 Tonne).*

Printed in England for HMSO
Dd. 715311 C30 7/83 398/1



PLAN 1

Location of premises